Bus Inf Syst Eng 57(1):51–59 (2015)
DOI 10.1007/s12599-014-0360-2

RESEARCH PAPER

e^3 service: A Critical Reflection and Future Research

Iván S. Razo-Zapata · Jaap Gordijn ·
Pieter de Leenheer · Roel Wieringa

Received: 28 February 2014 / Accepted: 15 October 2014 / Published online: 10 February 2015

Abstract Commercial services are of utmost importance for the economy. Due to the widespread use of information and communication technologies, many of these services may be delivered online by means of service value networks. To automate this delivery, however, issues such as composition, integration, and operationalization need to be addressed. In this paper, the authors share their long-term vision on composition of service value networks and describe relationships with fields such as cloud computing and enterprise computing. As a demonstration of the state of the art, capabilities and limitations of *e^3 service* are described and research challenges are defined.

Keywords Service value networks · *e^3 service* · Composition · Ontologies · Service computing · Enterprise computing

Accepted after two revisions by the editors of the special focus.

I. S. Razo-Zapata (✉)
Vrije Universiteit Brussel, Brussels, Belgium
e-mail: ivan.razo.zapata@vub.ac.be

Assoc. Prof. J. Gordijn
VU University, Amsterdam, The Netherlands
e-mail: j.gordijn@vu.nl

Dr. P. de Leenheer
Collibra nv/sa, Brussels, Belgium
e-mail: pieter@collibra.com

Prof. Dr. R. Wieringa
Universiteit Twente, Enschede, The Netherlands
e-mail: R.J.Wieringa@utwente.nl

1 Introduction

Increasingly, commercial service innovation is enabled by information and communication technologies (ICT). For instance, in the entertainment industry, digital resources such as music and video are delivered via the Internet (Premkumar 2003). The delivery of these resources is a commercial service because customers have to pay for it, or have to accept ads.

Information technology is not only an enabling factor for many services, rather such technology is the actual service. Take for example content storage services (e.g., data storage in the cloud). Here, information technology plays a crucial role in developing and providing *commercial* services themselves.

To develop ICT components, it is common practice to state first requirements and designs in terms of *conceptual* models (e.g., cf. the UML set of diagrams). We argue to use such type of conceptual models also for developing the business understanding of a service at hand. For this purpose, we have presented *e^3 value* (Gordijn and Akkermans 2003) and *e^3 service* (De Kinderen et al. 2013; Razo-Zapata et al. 2012), and its predecessor *serviguration* (Baida et al. 2003), which resemble a model-based concept of working, but use a business-oriented terminology.

Commercial services require at least two parties, namely a customer and a supplier. However, often more than one supplier is involved. For instance, to obtain a music stream, a user needs a content provider for the stream itself, but also needs an Internet Service Provider (ISP) for having Internet access. Therefore, services are provided and consumed in networks, which we call *service value networks* (*SVNs*) (see e.g., Basole and Rouse 2008; Allee 2002; Razo-Zapata et al. 2012).

SVNs can be manually designed beforehand, e.g., by business developers of participating companies. However,

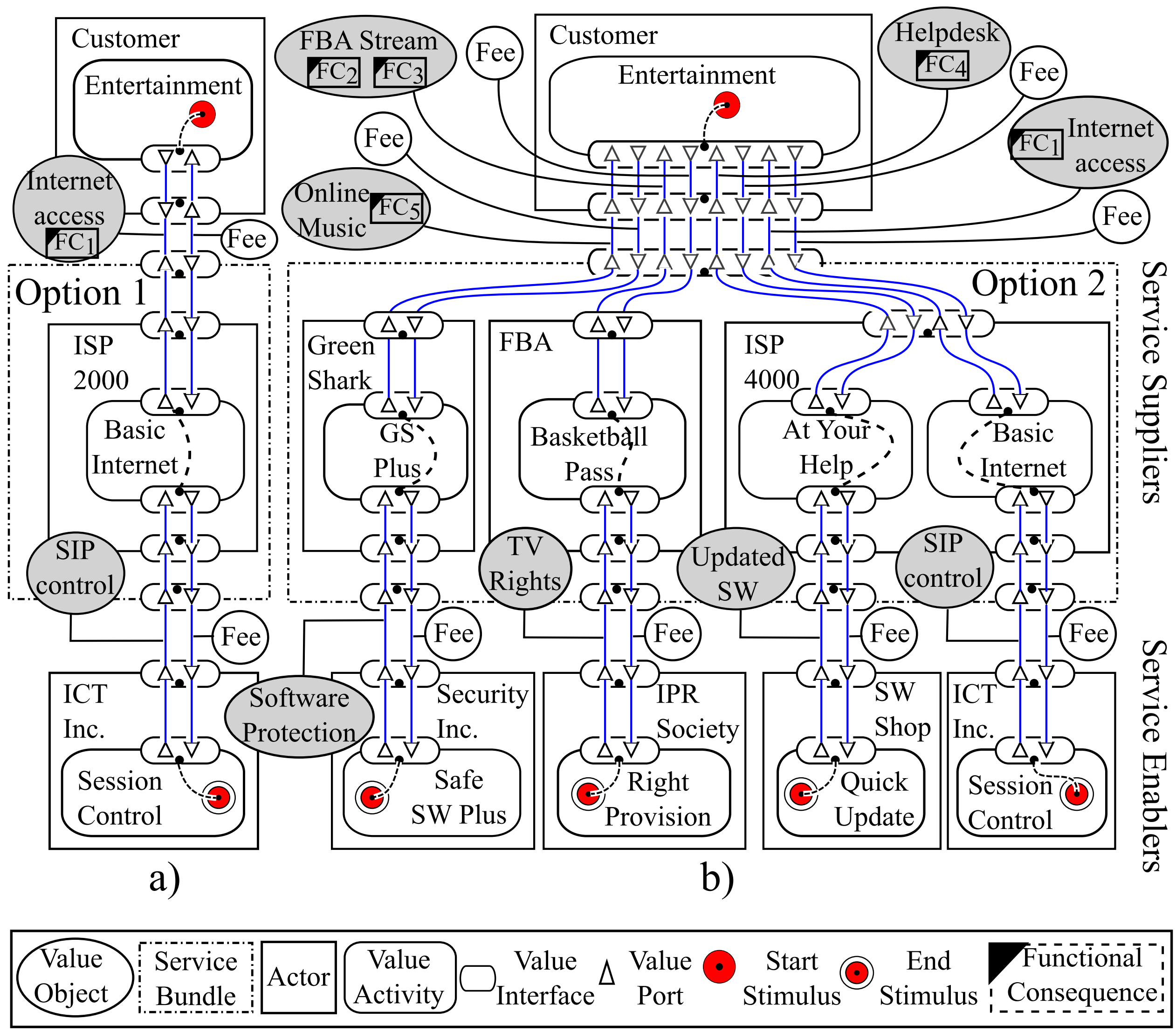

Fig. 1 Two service value networks modeled as e^3*value* models

since many services are actually ICT services, a logical next step is to automatically compose *SVNs*, given a customer need.

In this paper, Sect. 3 explains our vision of *SVN* composition, in relation to other efforts. In Sect. 4, we discuss e^3*service* as a way to semi-automatically compose *SVNs*. Then, this paper contributes a critical reflection on e^3*service* (see Sect. 5). Based on this reflection, an *SVN* research agenda is presented in Sect. 6, in addition to Gordijn et al. (2012). We illustrate our vision and research vision by means of an illustrative online entertainment example (Sect. 2).

2 Example: The Online Entertainment Marketplace

Based on previous case studies (Gordijn et al. 2011) and new ways of delivering multimedia content (Premkumar 2003), we have developed an educational example to describe the elements within our long-term vision as well as future research challenges with respect to e^3*service*.

Our example assumes that a customer wants to compose an entertainment service out of elementary services. For example, as shown in Fig. 1a [cf. the annotated e^3*value* notation (Gordijn and Akkermans 2003)], a service bundle may include only basic Internet access. In this way, the bundle consists of only one actor (ISP 2000) performing one single service (Basic Internet), which offers the value object (Internet access) in exchange for the other value object (Fee). In addition, the Internet service may also depend on other services (service enabler) such as SIP[1] control to implement Voice over IP (VoIP), which is outsourced to a third actor.

[1] Session Initiation Protocol.

In contrast, as depicted in Fig. 1b, a service bundle may contain services such as basic Internet access, a help desk, a streaming service and an online music service. All these services can potentially be offered by different suppliers, so that a multi-supplier service bundle emerges. Similar to Fig. 1a, services mentioned by Fig. 1b may also depend on service enablers. For instance, "GS Plus" may require software protection from reverse engineering, which can be outsourced to a third actor such as "Security Inc."[2]

The focus of the models is on what kind of objects must be transferred in order to cover customer needs. (a) An *SVN* for a customer need demanding FC1 (connection to Internet). (b) An *SVN* for a more elaborated need demanding FC1, FC2 (Online Basketball), FC3 (FBA press conferences), FC4 (Tech support) and FC5 (Classic recorded concerts).

3 Vision of the Composition of Service Value Networks

As many other systems, *SVNs* exhibit both *inherent* (due to the number, existence and nature of internal interactions) and *epistemic* (because our limited knowledge about their properties) complexity (Basole and Rouse 2008; Sommerville et al. 2012). To address these types of complexity, we have conducted substantial research (Akkermans et al. 2004; Baida et al. 2003; De Kinderen et al. 2013; Razo-Zapata et al. 2012). Nonetheless, the current state of the art of e^3*service* is still at quite a distance from our long-term vision, which can be characterized by four elements: a multi-perspective view, integration, market-based composition and resilient *SVNs* (Gordijn et al. 2012). While the first two elements deal with *epistemic* complexity, the last two address *inherent* complexity.

3.1 A Multi-Perspective View of Service Value Networks

Since *SVNs* represent complex interactions between customer, service suppliers and enablers, they are influenced by at least four perspectives: economic, social, political and technological (Basole and Rouse 2008). In a similar vein, efforts such as the Unified Service Description Language (USDL) focus on three perspectives: business (usually dealing with economic and political issues, too), technical/software and operational/platform (Cardoso et al. 2010; Barros and Oberle 2012). Consequently, given the complexity of integrating several perspectives within *SVNs*, a multi-perspective integration framework is yet to be developed.

3.1.1 The Business Value Perspective

We assume a critical separation between business value and business process aspects since the former is focused on *what* commercial services offer and *what* they want in return; whereas the latter is centered on *how* the transfers are achieved in terms of operational processes. We separate the 'what' from the 'how', because to our experience, it is already quite difficult to create a shared and agreed understanding of which commercial services are offered and requested by whom in the first place. E.g., in the online entertainment market it might be important to analyze *what* objects of economic value (digital resources such as tracks, streams, and money) are transferred among actors as well as the sustainability of composite *SVNs*.

3.1.2 The Business Process Perspective

As we are interested in fully operational *SVNs* with automated coordination, we must provide means to allow orchestration and choreography (Papazoglou 2008) of web services that can execute *SVNs*' processes. E.g., once a customer decides to acquire an *SVN*, a cross-organizational business process must start to coordinate the transfer of digital and monetary resources. The business process perspective answers the 'how' question as discussed in the previous section.

3.1.3 The ICT Perspective

Since we assume that *SVNs* can be composed of machine-readable and executable commercial services, an ICT architecture should be specified, preferably a Service Oriented Architecture (SOA) (for instance, cf. web services) (Papazoglou 2008; Pautasso et al. 2008). Nonetheless, it might be also possible that more than one web service is required to implement a single commercial service. E.g., a commercial service offering online music might be implemented by web services such as audio streaming, tracks downloading and audio compression.

SAP's USDL has a number of modules to describe services, amongst others the *service* and *technical* module (Barros and Oberle 2012). The *service* module describes the service, e.g., in terms of *Service, CompositeService* and *ServiceBundle* whereas the *technical* module describes technical interfaces, e.g., described c.f. WSDL.

Microsoft proposes an ontology and taxonomy (OT) of "software services" (Cohen 2007). The ontology defines the characteristics of services: *main purpose, interface, state management, transactions, error handling, security, management/governance, how built*. The taxonomy provides a classification of services: *Bus Services, Communication Services, Utility Services, Application Services,*

[2] E.g., Spotify, a popular music service, uses Morpher as its software protection provider.

Table 1 Multiple perspectives on *SVNs*, integration strategies, and current approaches

Approaches	Value perspective	Process perspective	ICT perspective	Integration
USDL	Service, legal, interaction, pricing, functional participants, technical, service level			
OT		Process services	Bus, Capability services	
e^3*alignment*	e^3*forces*	UML activity diagrams		Req. Eng. Alignment within a perspective
	e^3*value*	IS architecture		Alignment between perspectives
EI	Goal and value modeling	Choreography Orchestration	Web services	MDA and SOA
CC		Choreography orchestration	SaaS, PaaS	SOA, ITIL V3
			IaaS	ESB
BSM		UML2 collaboration	Object-oriented technology	Business services specifications

Entity Services, Capability Services, Activity Services, and *Process Services*.

3.2 Integration

These perspectives must be integrated to provide a clear blueprint of the composite *SVN*. Approaches such as e^3-*alignment* provide a valuable foundation to achieve such integration since it enables to design and analyze inter-organizational business-ICT taking into account four perspectives: strategic, value, process, and IS interactions (Pijpers et al. 2012).

Other research areas such as enterprise interoperability (EI) (van Sinderen 2008), cloud computing (CC) (Mell and Grance 2011), and Business Services Modeling (BSM) (Amsden 2005) can also provide insights to achieve this integration. EI, also referred as enterprise computing, aims at providing to enterprises the ability to interoperate for achieving their business goals while taking care of the cross-organizational, cross-jurisdictional, and cross-domain nature of business collaborations (van Sinderen 2008). In this way, enterprises must not only align business goals with ICT infrastructure internally but also enable effective and efficient inter-enterprise collaborations (van Sinderen 2008). The business perspective is usually addressed as a goal or value modeling problem, whereas the process perspective is mostly solved by applying choreography and orchestration of business processes. Finally, the ICT perspective relies mainly on software (web) services (van Sinderen 2008; Khadka et al. 2013).

CC "is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources" (Mell and Grance 2011). Although CC is well supported by academia and industry, there is limited information on how CC deals with business aspects (Commission 2012). Some industrial approaches take a managerial perspective by proposing the use of the IT Infrastructure Library (ITIL V3), which addresses service management as the capability for providing value to customers in the form of (IT) services (IBM 2010). Other approaches propose the use of strategies such as Enterprise Service Bus (ESB) (Chen 2012).

Finally, IBM's BSM aims at bridging the gap between business requirements and the architecture of IT solutions that are intended to meet them (Amsden 2005). BSM uses "Business Services Specifications" (BSS) that can mediate between business operational requirements (business processes represented as collaborations in UML2) and the final implementation by providing a specification of *what those implementations must do* to meet the requirements (Amsden 2005). Table 1 summarizes how USDL, OT, e^3*alignment*, EI, CC, and BSM can provide insights on *SVN*'s multiple perspectives as well as on integration issues.

3.3 Market-based composition of *SVNs*

SVNs might be composed in at least two fashions: hierarchical and self-organized. We have extensively explored hierarchical approaches where customers drive the composition of *SVNs* in a top-down manner (Baida et al. 2003; De Kinderen et al. 2013; Razo-Zapata et al. 2012). Nonetheless, self-organized approaches might be also suitable for this task. For instance, multi-agent systems can be applied to provide a bottom-up composition (Shoham and Leyton-Brown 2008). In this way, the composition task can be modeled as a coalitional game theory problem in which service suppliers build up coalitions (e.g., service bundles) to achieve a goal (e.g., obtain good payoffs while solving a customer need) (Shoham and Leyton-Brown 2008).

Moreover, we also consider that the decision on whether to apply hierarchical or self-organized composition depends on the nature of the market, i.e. self-organized composition could be applied to highly complex markets where there is a huge diversity of customers and suppliers. For instance, Basole and Rouse have identified that fragmented markets such as retail and telecom are much more complex (i.e. there is a big amount of participants, customers and suppliers) than consolidated markets such as aerospace (Basole and Rouse 2008). In this way, hierarchical approaches may be applied to markets such as aerospace as there are relatively few aerospace suppliers compared to retail and telecom, for which self-organized approaches could be more suitable since the complexity is higher.

3.4 Resilient *SVNs*

Once *SVNs* are deployed by means of ICT services, we must monitor its performance to avoid undesirable situations such as drops in Quality of Service (QoS), decrease in value, or unavailable suppliers, which may diminish its performance. Our final goal is to provide *SVNs* with resilient capabilities to adapt to changes. To this aim, we must deal with at least the following issues:

- *Monitoring* We must continuously monitor *SVN*'s performance to *detect* changes that can degrade *SVN*'s quality or value. As changes can cause an *SVN* to become completely inoperable or partially compromised, we would like to monitor whether value transfers are achieved as expected.
- *Recomposition* If an *SVN* becomes inoperable, recomposition is required to either build up a new fully functional *SVN* or an operational *SVN* with "nearly acceptable" performance. E.g., a recomposed *SVN* could provide a borderline *QoS* at lower cost, which may still satisfy the customer need.
- *Adaptation* Whenever *SVN*'s performance is affected (due to recomposition or degradation), we must adapt it to meet again customer required specifications. While adaptation may require changing/replacing few services, we believe recomposition may require building up new *SVNs*.

Finally, we believe that recomposition and adaptation can be addressed either as a design problem (Razo-Zapata et al. 2012) or as a (re)configuration design problem where all possible solutions (recompositions/adaptations) adhere to a *common solution template* (Motta 1999). For instance, in Razo-Zapata et al. (2010), we have already proposed a mechanism to compose *SVNs* based on skeletons (templates that capture knowledge about *SVN*'s structural properties).

4 *e^{3}service* as an Example of *SVN* Composition

Research around *SVNs* is vast and deals with issues like value co-creation, business and ICT alignment, modeling, automated composition, among others (Basole and Rouse 2008; Hefley et al. 2010). The *e^{3}service* ontology semi-automatically composes *SVNs* matching customer needs. The *e^{3}service* consists of two parts: (1) knowledge representation of customer needs and available services, and (2) reasoning about composition.

4.1 Knowledge Representation to Address Epistemic Complexity

Customers consider services from a customer need perspective, whereas suppliers think of services in terms of packages offered to the customer. The *e^{3}service* ontology uses the notion of *functional consequence* (FC) to match both worlds. A consequence is any kind of result (physiological or psychological) acquired by consuming a valuable resource (tangible or intangible) (De Kinderen et al. 2013; Razo-Zapata et al. 2012). Customers obtain valuable consequences to satisfy their need; suppliers offer one or more consequences as a result of service provisioning.

The *e^{3}service* customer need ontology describes customer needs using terminology from marketing (De Kinderen et al. 2013). Key notions in the ontology are *need, consequence* and *want* (De Kinderen et al. 2013). A need is a basic human requirement that can be *specified* (*concretized*) by means of one or more consequences, whereas a want is a commercial solution containing consequences that can be provisioned on its own (De Kinderen et al. 2013). In the latest work on *e^{3}service* we focus mainly on *functional consequences* (*FCs*), which represent the functional goal that can be achieved through consumption of a valuable resource (Razo-Zapata et al. 2012).

Example In Fig. 1b the customer need "How can I get entertainment while at home?" can be *specified* by specific *FCs* such as *connection to Internet* and *online basketball* that might be respectively contained in wants such as *Internet access* and *FBA Stream*, which are commercial solutions (Razo-Zapata et al. 2012).

The supplier-oriented part of the *e^{3}service* ontology utilizes *e^{3}value* (Gordijn and Akkermans 2003) and considers service suppliers as *actors* performing value activities (*commercial services*) that produce service outcomes (*value objects*), with consequences, which can be offered to customers.

Example Fig. 1b depicts the actor "FBA" performing the value activity "Basketball Pass" that produces the value object "FBA Stream", which contains *FC2* and *FC3* (Razo-Zapata et al. 2012).

4.2 Computer-Supported Composition to Address Inherent Complexity

To reason about service bundles, Baida et al. proposed an algorithm that automatically bundles services using customer needs and dependency relationships among services

(Baida et al. 2003). De Kinderen et al. used a problem-solving method for matching customer needs to pre-composed multi-supplier service bundles (PCM2) (De Kinderen et al. 2013).

Recently, Razo-Zapata et al. (2012) have applied the so-called Propose-Verify-Critique-Modify (PVCM) problem-solving method to compose *SVNs* matching customer needs. PVCM removes two important assumptions made by Baida and De Kinderen. First, since Baida's bundling algorithm focuses on services and their interdependencies, the bundling process is limited by the number of optional services to be bundled (i.e. it assumes a small number of services[3]) (Baida et al. 2003). Second, De Kinderen assumes that service bundles are pre-composed (De Kinderen et al. 2013). In PVCM, the propose subtask automatically bundles services (no pre-composed bundles anymore) matching a customer need and assumes a bigger search space by focusing on *FCs* rather than services (Razo-Zapata et al. 2012).

5 Critical Reflection on *e³service*

5.1 Multiple Perspectives

Since *e³service* deals mainly with a business value perspective on services, issues regarding business process and ICT perspectives are mostly overlooked. Some efforts have been done to combine *e³value* models with process-oriented approaches (e.g., Schuster and Motal 2009; Fatemi 2012). However, the link between *value* and *ICT* perspectives remains highly unexplored (see Sect. 6.2).

In addition, regarding the value perspective, since *e³service* can compose *SVNs* combining single services with unique *pricing* schemes, it must also provide ways to compute consistent pricing schemes for bundles composed of several services (see Sect. 6.1). In De Kinderen et al. (2013), a pricing ontology has been proposed for pre-composed bundles, which can be extended to use with automatically composed *SVNs*.

5.2 Integration

Since both *e³alignment* and *e³service* are compatible with and inspired on *e³value*, it is reasonable to use them together to integrate value, process and ICT perspectives. However, since *e³alignment* deals mostly with the integration of the value and process perspective, some technique(s) must be developed to integrate the ICT perspective (based on web services perhaps).

[3] A search space containing over 20 services already exhibits scalability issues.

5.3 Market-Based Composition

The *e³service* ontology currently supports at least three approaches on hierarchical composition of *SVNs*, namely Serviguration, PCM2 and PVCM (Baida et al. 2003; De Kinderen et al. 2013; Razo-Zapata et al. 2012), which have been applied to different sectors such as music, education, health care, energy among others (Razo-Zapata et al. 2012). Nonetheless, *e³service* may be enriched by self-organized approaches to address issues such as scalability (i.e. how many services can be considered to compose *SVNs*), which has been previously observed by Serviguration (Baida et al. 2003) and PCVM (Razo-Zapata et al. 2012) (see also Sect. 6.3). In addition, Gordijn et al. (2012) argue that a self-organized approach has also a business consequence, namely that selecting the actors providing the services is not done anymore by a powerful central actor, but by the market itself.

5.4 Resilient *SVNs*

Although our current vision on resilient *SVNs* is composed of monitoring, recomposition and adaptation, *e³service* mostly provides solutions only for recomposition since approaches such as PVCM can recompose *SVNs* based on feedback provided by customers about required *FCs* (Razo-Zapata et al. 2012). As *e³service* has no mechanisms to address neither monitoring nor adaptation, extensions must be made to fully provide resilient *SVNs*.

Based on our long-term vision, Table 2 summarizes which issues have been solved, partially solved and unsolved in *e³service*. For instance, the value perspective is solved as *e³service* provides a sound mechanism to model the exchange of valuable resources, which meets our vision (see Sect. 3.1.1).

5.5 Other Approaches

First, the *e³value* and *e³service* ontologies can be used as a business development tool. A group of business developers and/or consultants then uses the ontologies as a conceptual modeling instrument, to create a shared understanding of the business case a hand. The Business Model Ontology (BMO) (Osterwalder 2004) (later: Business Model Canvas (BMC) (Osterwalder and Pigneur 2010)) is an approach for business model development. In contrast to *e³value*, BMO takes a particular enterprise as a point of departure, and considers, amongst others, the business network surrounding this enterprise. The *e³value* makes no explicit distinction between suppliers and customers but treats parties as equal citizens, thereby taking a business network perspective. The Resource Event Agent (REA) ontology (Geerts and McCarthy 1999), added with a graphical

Table 2 Summary of solved, partially solved and unsolved parts

	Epistemic issues		Inherent issues	
	Multiple perspectives	Integration	Market-based composition	Resilient *SVNs*
Solved	Value perspective	Value perspective	Hierarchical composition	Recomposition
Partially	Process perspective (Fatemi 2012)	Process perspectives (Pijpers et al. 2012)		Monitoring (Silva and Weigand 2012)
	Pricing schemes			
	(De Kinderen et al. 2013)			
Unsolved	Pricing bundles		Bundling and optimization	Monitoring
	Value and ICT duality			

syntax (Sonnenberg et al. 2011), focuses amongst others on resources. REA provides a generic view on economic activity, in terms of resources. The *e^{3}service* ontology adds to such a generic view a specialization about the notion of services, and modeling and reasoning about multi-supplier service bundles that satisfy a complex customer need.

Second, the *e^{3}value* and *e^{3}service* ontologies may facilitate semi-automatic reasoning about *SVNs*. Currently, such reasoning is useful for developing and understanding the service catalog of an enterprise (and its partners). Tool support can be used to understand which alternative service bundles are possible given a customer need as these tools can enhance the design of *process models based on value exchanges* (Razo-Zapata et al. 2012; Fatemi 2012) and the analysis of economic issues such as profitability (Fatemi 2012).

6 Research Agenda

6.1 Pricing Complex Bundles

Theme Multi-perspective.

Description Although service bundles are composed of one or more single services, they are sold for a single price. Therefore, it is necessary to compute final prices for bundles as well as the amount of money to be distributed among each single service within bundles. In addition, some observations have to be taken into account (e.g., De Kinderen et al. 2013; Monroe 1990). First, the price of a single service can be fixed, usage-based or a combination of both. Second, discounts may apply to the prices of single services when bundled.

Example In Fig. 1b the service bundle contains four services (provided by different suppliers) for which the customer must pay some money. Consider for instance that GS Plus, At Your Help and Basic Internet services are offered at a fixed price, whereas Basketball Pass is offered under a usage-based scheme (perhaps per viewed game). In addition, when acquiring Basketball Pass combined with other services, discounts apply. To compute a final price for a given bundle, we must compute all pricing schemes as well as determine under which conditions discounts might apply. Finally, the money being paid by the customer must be repartitioned among suppliers.

Foreseen solution To address this issues we can rely on research previously conducted by De Kinderen et al. who have already proposed a pricing model for pre-composed bundles (De Kinderen et al. 2013), USDL that provides a pricing module for services (Barros and Oberle 2012), or Becker et al. who have designed a language to price bundles containing products and related value-added services (Becker et al. 2011).

6.2 Value and ICT Duality

Theme Multi-perspective and integration

Description Even though the link between value and process perspectives has been largely explored (see Schuster and Motal 2009; Pijpers et al. 2012; Fatemi 2012), the link between value and ICT perspectives is usually overlooked. Nonetheless, value and ICT perspectives must be described and integrated to deliver fully operational *SVNs* as commercial services will then contain information regarding value, process and ICT issues.

Example In Fig. 1 services offered by suppliers and enablers provide information about value issues such as business to customer (B2C) and business to business (B2B) relationships (value transfers between the customer, suppliers and enablers); nonetheless, there is no information regarding what type of ICT services can be used to realize such services. For instance, there must be information on what kind of ICT services can be used to provide the service "GS Plus" provided by "Green Shark" since many technologies can be used, e.g., web services for streaming or downloading video.

Foreseen solution In Rolland et al. (2010), the authors present an MDA-based approach for linking software services (mainly web services with WSDL and BPEL descriptions) to so-called intentional services that might meet business-oriented requirements such as goals. We can follow a similar approach in which value-oriented service descriptions are linked to operational services by using MDA techniques. For instance, we could define a metamodel capturing concepts of value and ICT models; the metamodel could be used to define model transformations for linking value-oriented services to ICT services.

6.3 Service Bundling Meets Combinatorial Optimization

Theme Market-based composition.

Description To provide e^3*service* with a toolkit to compose *SVNs* for different types of markets, we must first address scalability issues for our hierarchical algorithms (Razo-Zapata 2014). Although our current algorithm can handle a considerable number of services (up to 1000), they cannot deal with high numbers of customer requested functionalities (Razo-Zapata 2014). In Razo-Zapata (2014) we have explained that composing *SVNs* might take up to 80 s for several requested functionalities.

Example Our current algorithm can handle service catalogs containing 1000 services which provide on average ten *FCs*; however, once a customer requests more than 15 *FCs* the composition takes a considerable amount of time.

Foreseen solution Since bundling services aims at building up a combination of services to match a customer's need, to improve the scalability of our algorithm, we can model the bundling problem as a combinatorial optimization problem. In this way, approaches such as parallel computing (Baase and van Gelder 2000) can be applied. For instance, since in Razo-Zapata (2014) we have already defined a bundling process based on computing and combining service clusters to generate solutions, a next step might be to use parallelism so that service clusters are computed and combined faster.

6.4 *SVN* Monitoring

Theme Resilient *SVNs*.

Description As *SVNs* are exposed to changes due to its complexity, we have to provide ways to *monitor* their behavior and *detect* when changes compromise their performance.

Example The *SVN* in Fig. 1b is exposed to changes in at least three contexts (value, process, and ICT). For instance, suppose that the "Basketball Pass" service is realized by a video streaming web service that suddenly becomes unavailable; as a consequence transferring the resource "FBA Stream" to the customer is not longer possible due to the technical failure. Therefore, a monitoring scheme must allow to detect such failure so that an adaptation strategy can be applied.

Foreseen solution e^3*service* can try to reuse previously developed ontologies such as e^3*control* (Kartseva et al. 2009) or the so-called Value Monitoring Ontology (VMO) (Silva and Weigand 2012), which both provide methods for monitoring networks of activities based on e^3*value* constructs. In addition, the proposed solution must also address detection as it is important to know when *SVNs* are experiencing deviations from expected behavior, i.e. changes about QoS, decrease in value or unavailable suppliers. For instance, VMO offers the possibility to define monitoring policies for critical activities within an *SVN*. In our example, it would be possible to define policies for services such as "Basic Internet" and "Basketball Pass".

By no means, the list of challenges is complete. Issues such as software support for integration and *SVN* adaptation are not discussed due to space restrictions. In addition, more challenges have already been described in (Gordijn et al. 2012), such as ontological issues for matching customer and suppliers, detailed mapping from customer needs onto specific requirements and web service support for e^3*service*. Furthermore, other challenges can be found by considering Service Dominant Logic (SDL) (Vargo and Lusch 2004), e.g., by taking into account the role of the customer as service co-producer.

7 Conclusions

In this paper, we have introduced a number of research challenges with respect to commercial service value networks in general and e^3*service* in particular.

The contribution of this paper is threefold. First, we shared our long-term vision on *SVN* composition, where we also discussed overlaps and connections with other approaches such as USDL, IBM's Business Service Modeling (BSM), cloud computing, and enterprise interoperability.

Second, we also presented our experiences on value-driven service composition and provided a critical reflection by describing the state of the art of e^3*service*. We explained how addressing *epistemic complexity* has improved our understanding of services and *SVNs*. We briefly described the two perspectives in e^3*service* (customer need and service supplier) that allow us to design, compose and analyze *SVNs*. Likewise, we also described different composition approaches (Baida et al. 2003; De Kinderen et al. 2013; Razo-Zapata et al. 2012) to handle business to customer (B2C) and business to business (B2B) relationships, which help us to address *inherent complexity*.

Third, we described a research agenda to push e^3*service* closer to our long-term vision, which encompasses four elements: a multi-perspective view on *SVNs*, integration, market-based composition of *SVNs* and resilient *SVNs*.

Acknowledgments This paper has been partially funded by the NWO/Jacquard projectVALUE-IT no 630.001.205.

References

Akkermans H, Baida Z, Gordijn J, Pena N, Altuna A, Laresgoiti I (2004) Value webs: using ontologies to bundle real-world services. IEEE Intell Syst 19(4):57–66

Allee V (2002) A value network approach for modeling and measuring intangibles. In: Transparent Enterprise Conference

Amsden J (2005) Business services modeling. Technical report, IBM developerWorks

Baase S, van Gelder A (2000) Computer algorithms: introduction to design and analysis, 3rd edn. Addison-Wesley Longman, Boston

Baida Z, Akkermans H, Gordijn J (2003) Serviguration: towards online configurability of real-world services. In: 5th international conference on electronic commerce (ICEC '03). ACM, New York, pp 111-118

Barros A, Oberle D (2012) Handbook of service description USDL and its methods. Springer, Heidelberg

Basole RC, Rouse WB (2008) Complexity of service value networks: conceptualization and empirical investigation. IBM Syst J 47:53–70

Becker J, Beverungen D, Knackstedt R, Müller O (2011) Pricing of value bundles: a multi-perspective decision support approach. Enterp Model Inf Syst Archit 6(2):54–69

Cardoso J, Barros A, May N, Kylau U (2010) Towards a unified service description language for the internet of services: requirements and first developments. In: Proc 2010 IEEE (SCC '10), Washington, DC, pp 602–609

Chen L (2012) Integrating cloud computing services using Enterprise Service Bus (ESB). Bus Manag Res 1(1):26–31

Cohen S (2007) Ontology and taxonomy of services in a service-oriented architecture. Archit J 11:30–35

Commission, European (2012) A roadmap for advanced cloud technologies under h2020: recomendations by the cloud expert group. Technical report, European Union

de Kinderen S, de Leenheer P, Gordijn J, Akkermans H, Dröes R-M, Meiland F (2013) e3service: an ontology for needsdriven real-world service bundling in a multi-supplier setting. Appl Ontol 8(4):195–229

de Silva PA, Weigand H (2012) Monitoring value webs. In: Albani A, Aveiro D, Barjis J (eds) EEWC. Springer, Heidelberg, pp 108–123

Fatemi H (2012) Risk-aware design of value and coordination networks. Ph.D. thesis, University of Twente

Geerts GL, McCarthy WE (1999) An accounting object infrastructure for knowledge-based enterprise models. IEEE Intell Syst 14(4):89–94

Gordijn J, Akkermans JM (2003) Value-based requirements engineering: exploring innovative e-commerce ideas. Requir Eng 8:114–134. doi:10.1007/s00766-003-0169-x

Gordijn J, de Leenheer P, Razo-Zapata IS (2011) Generating service valuewebs by hierarchical configuration: an IPR case. In: Proc HICSS 44

Gordijn J, Razo-Zapata IS, de Leenheer P, Wieringa R (2012) Challenges in service value network composition. In: 5th IFIP WG8.1 working conference on the practice of enterprise modelling, PoEM

Hefley WE, Lamparter S, Nikolaou C, Tai S (eds) (2010) Dagstuhl perspectives workshop: service value networks – executive summary and abstracts collection, number 10301. In: Dagstuhl Seminar Proceedings, Dagstuhl, Germany

IBM (2010) Integrated service management and cloud computing: more than just technology best friends. Technical report, IBM

Kartseva V, Gordijn J, Tan Y-H (2009) Designing value-based inter-organizational controls using patterns. In: Lyytinen K, Loucopoulos P, Mylopoulos J, Robinson B (eds) Design requirements engineering: a ten-year perspective. Lecture Notes in Business Information Processing 14:276–301. Springer, Heidelberg

Khadka R, Sapkota B, Ferreira Pires L, van Sinderen M, Jansen S (2013) Model-driven approach to enterprise interoperability at the technical service level. Comput Ind 64:951–965

Mell P, Grance T (2011) The NIST definition of cloud computing. Technical Report 800-145, National Institute of Standards and Technology (NIST), Gaithersburg

Monroe K (1990) Pricing: making profitable decisions. McGraw-Hill, New York

Motta E (1999) Reusable components for knowledge modelling: case studies in parametric design problem solving. IOS Press

Osterwalder A (2004) The Business Model Ontology – a proposition in a design science approach. Ph.D. thesis, University of Lausanne, Ecole des Hautes Etudes Commerciales HEC

Osterwalder A, Pigneur Y (2010) Business model generation: a handbook for visionaries, game changers, and challengers. Wiley, New Jersey

Papazoglou MP (2008) Web services: principles and technology. Pearson Education, New Jersey

Pautasso C, Zimmermann O, Leymann F (2008) Restful web services vs. big web services: making the right architectural decision. In: 17th international conference on World Wide Web, WWW '08, pp 805–814

Pijpers V, de Leenheer P, Gordijn J, Akkermans H (2012) Using conceptual models to explore business-ICT alignment in networked value constellations. Requirs Eng 17:203–226. doi:10.1007/s00766-011-0136-x

Premkumar G (2003) Alternate distribution strategies for digital music. Commun ACM 46:89–95

Razo-Zapata IS (2014) Service value networks. Ph.D. thesis, VU University Amsterdam

Razo-Zapata IS, Chmielowiec A, Gordijn J, van Stehen M, de Leenheer P (2010) Generating value models using skeletal design techniques. In: 5th international BUSITAL workshop

Razo-Zapata IS, de Leenheer P, Gordijn J, Akkermans H (2012) Fuzzy verification of service value networks. In: Ralyte J, Franch X (eds) 24th int conf on advanced information systems engineering (CAiSE'12). Springer, Heidelberg

Rolland C, Kirsch-Pinheiro M, Souveyet C (2010) An intentional approach to service engineering. IEEE Trans Serv Comput 3(4):292–305

Schuster R, Motal T (2009) From e3-value to REA: modeling multi-party e-business collaborations. In: Proc 2009 IEEE conference on commerce and enterprise computing, CEC '09, Washington, DC, pp 202–208

Shoham Y, Leyton-Brown K (2008) Multiagent systems: algorithmic, game-theoretic, and logical foundations. Cambridge University Press, New York

Sommerville I, Cliff D, Calinescu R, Keen J, Kelly T, Kwiatkowska M, Mcdermid J, Paige R (2012) Large-scale complex IT systems. Commun ACM 55(7):71–77

Sonnenberg C, Huemer C, Hofreiter B, Mayrhofer D, Braccini A (2011) The REA-DSL: a domain specific modeling language for business models. In: Mouratidis H, Rolland C (eds) Advanced information systems engineering. Lecture Notes in Computer Science 6741, Springer, Heidelberg, pp 252–266

van Sinderen M (2008) Challenges and solutions in enterprise computing. Enterp Inf Syst 2(4):341–346

Vargo SL, Lusch RF (2004) Evolving to a new dominant logic for marketing. J Mark 68(1):1–17